REP 1993-044

Nest-site Selection and Reproductive Biology of Roof- and Island-nesting Herring Gulls

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Introduction

Birds nesting on roofs is not a recent phenomenon. While storks (*Ciconia ciconia*) have historically nested on buildings throughout Europe and northern Africa (Lack 1968: 112–113). One of the earliest reports in North America was of a common nighthawk (*Chordeiles minor*) nesting on a warehouse roof in Philadelphia in 1869 (Bent 1940). Since that time, at least 23 species of birds have been reported to nest on roofs, 9 of which are gulls (*Larus* spp.) (*see* Fisk 1978, Blokpoel and Smith 1988).

The first report of gulls nesting on buildings was of herring gulls (*L. argentatus*) near the Black Sea during 1894 (Goethe 1960). Gulls have since been reported to nest on roofs throughout Europe and North America (Monaghan and Coulson 1977; Bourne 1979; Monaghan 1979, 1982; Albrecht 1986; Kumerloeve 1986; Blokpoel and Smith 1988; Vermeer et al. 1988; Vegelin 1989; Blokpoel et al. 1990; Dolbeer et al. 1990; Spaans et al. 1990). Use of urban areas by several species of gulls has increased substantially in recent years (Monaghan 1979, Vermeer et al. 1988, Vermeer 1992). Dolbeer et al. (1990), among others, suggested that roofs were suboptimal nesting habitat for herring gulls, hypothesizing that roof-nesting was a result of the dispersal of breeding adults in a population experiencing rapid growth and lacking more suitable nest sites. Similar dispersal of herring gulls to roofs and other urban sites subsequent to rapid growth of the original colony has been reported in other areas (Paynter 1963, Campbell 1975, Monaghan and Coulson 1977, Vermeer et al. 1988). Gulls colonizing roofs frequently have been considered to be younger, less experienced birds that were unable to compete for more desirable nest sites. However, little attention has been directed at the hypothesis that roofs may be favorable nesting habitat that only recently has been occupied (Monaghan 1979).

The objectives of this study were to compare herring gull reproductive parameters at a roof colony and a nearby island colony and to evaluate nest-site selection within the roof and island habitats. The goals were to determined (1) whether a roof population of nesting herring gulls was comprised of younger individuals than was the population at the earlier colonized island, and (2) breeding biology, especially nesting success, differed between the two colony sites.

Study Area

The study was conducted in northcentral Ohio during May through July 1992. The herring gull nesting concentration (1 of the largest of the Great Lakes with 3,250 nesting pairs in 1992) is located on Sandusky Bay, Lake Erie (Belant et al. 1993) (Figure 1). The first documented nesting of herring gulls in the area occurred on Turning Point Island (TPI), a 2.7-hectare dredge disposal island created in 1900 about 0.5 kilometer offshore from Sandusky, Ohio (Scharf et al. 1978). About 50 percent of the island has herbaceous vegetation. Dominant shrub and tree species include red mulberry (*Morus rubra*), red-osier dogwood (*Cornus stolonifera*) and eastern cottonwood (*Populus deltoides*, Scharf et al. 1978). Herring gulls have nested on TPI since at least 1976. The number of nesting pairs on TPI during 1976 and 1977 were 983 and 878, respectively (Scharf et al. 1978); in 1992 there was 1,918 nests (Belant et al. 1993).

The herring gull population on two adjacent, flat roofs in the Sandusky, Ohio business district about 1 kilometer east of TPI also was monitored (Figure 1). Both roofs, which combined comprised 1.3 hectares, contain structures (e.g., vents, skylights) on gravel, metal and tar surfaces. Scarf et al. (1978) did not report herring gulls nesting on these roofs during their surveys in 1976 and 1977. In 1992, 176 herring gull nests were present on the two roofs (Belant et al. 1993). No other gull species nested on TPI or the roofs.

Methods

Observations were made from early May-early July 1992. We monitored study nests on roofs one time weekly and, on TPI, on or two times weekly. On TPI, we marked 64 nests containing three eggs each by placing numbered 0.6-meter wire surveying flags about 1 meter from the nest. The 176 nests on roofs containing ≥ 1 eggs were marked individually by placing 5- $\times$ 10- $\times$ 20-centimeter numbered wooden blocks within 1 meter of them.

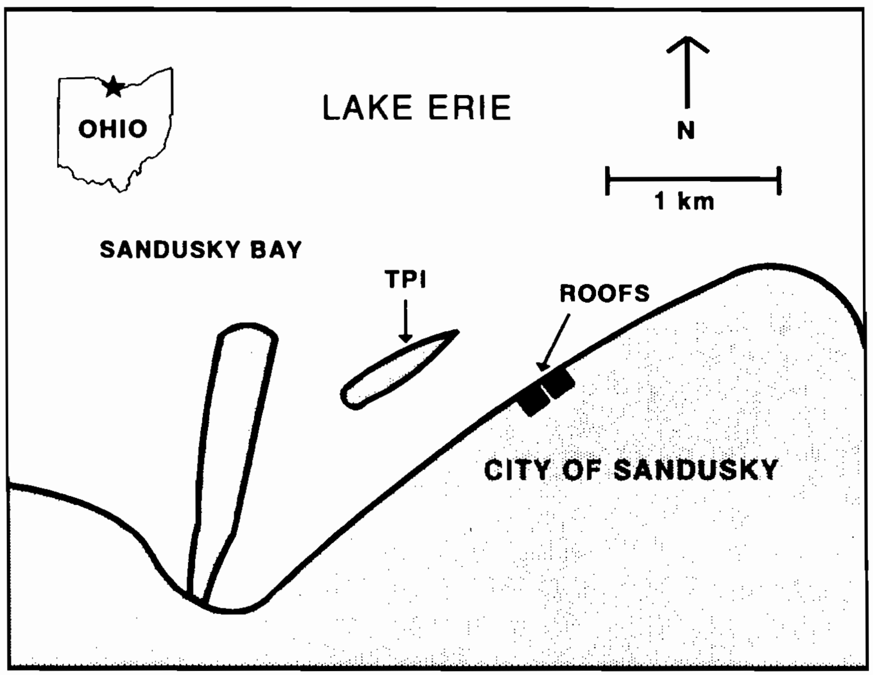

Figure 1. Location of herring gull nesting populations on Turning Point Island (TPI), Sandusky Bay, Lake Erie and on two roofs in Sandusky, Ohio.

Exotic Species in Urban Environments: Lessons from New England's Mute Swans

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Introduction

The mute swan (*Cygnus olor*) is a European species that often inspires images of nobility, romance and elegance owing to its natural beauty and its characterization in fairy tales (Wilmore 1974). Not surprisingly, this species has been introduced several times into North America as early as the nineteenth century to adorn estates, parks and zoos (Allin 1981). Some of these birds escaped or were released, resulting in the establishment of free-ranging populations in Michigan, Minnesota, Wisconsin, Wyoming, British Columbia, Ontario and in the Atlantic coastal states from Massachusetts to Maryland (Allin 1981). Along the Atlantic, free-ranging populations have increased to an estimated 5,300 in 1987 (Allin et al. 1987).

Despite their beauty and royal pedigree, these birds have not been universally welcomed. In North America, mute swans are an exotic species, and biologists recognize that the establishment of other exotic species, especially on oceanic islands, has decimated native fauna. Given this less than positive history of exotic species, biologists are concerned that increased populations of free-ranging mute swans may adversely impact native waterfowl populations. In particular, biologists worry about the swan's aggressive nature (Reese 1975, Williams 1989), and the potential impact of its foraging on aquatic vegetation (Allin 1987).

In a recent study, Conover and Kania (unpublished) examined the consequences of interspecific aggression by territorial mute swans on native waterfowl in southern New England. They found that swans engaged in high rates of interspecific aggression, directed primarily at mallards (*Anas platyrhynchos*), American black ducks (*A. rubripes*) and Canada geese (*Branta canadensis*). However, in most cases, the swan stopped its aggression when the threatened individual moved less than 10 meters. Swans did not keep native waterfowl from using these sites and were never observed to foil a nesting attempt by another waterfowl species.

Further, Conover and Kania (unpublished) examined the effect of swan herbivory on aquatic flora at freshwater ponds. They found no significant difference in above-ground plant biomass or species composition between sites where swans could graze and sites inside exclosures where they could not. These results indicate that mute swans, at least at the time of the study, did not have an adverse impact on native waterfowl populations at freshwater ponds. Left unanswered were the questions of what impact a much higher swan population might have at these sites or what impact swans might have in other areas, such as estuaries.

Currently, management plans for mute swans differ greatly among states. In various locales, these birds are protected, unprotected or actively controlled (Allin et al. 1987). In this study, we examined the perceptions of urban residents to assess their opinions of

Reproductive Parameters

During each visit to nests on roofs, clutch size and number of chicks present at the nest site were recorded. All nests with ≥ 1 eggs were used for comparisons of hatching success within roofs. Only three-egg clutches in roof nests were used for comparisons of hatching success on TPI (*see* Belant and Seamans 1993). Clutch size on TPI was estimated from a complete ground count of nests on May 1 by eight observers. To avoid double counting, a location on the ground within 1 meter of each nest was marked using spray paint.

Mean hatching dates for all study nests were estimated by interpolation based on the date of the previous check, the number of chicks that had hatched or were pipping, and the relative age of chicks (Kadlec et al. 1969). Clutch completion dates (using a 28-day incubation period) (Drent 1970, Pierotti 1982) were estimated by backdating from mean hatching dates. Hatching success was defined as the number of chicks hatched divided by the number of eggs laid for each comparison and is expressed as a percentage. The maximum length and width of each egg in 30 three-egg clutches on roof (15 clutches per roof) and 30 three-egg clutches on TPI were measured to the nearest 0.01 millimeter to calculate egg volume indices using the formula *length* $\times$ *width*^{2} (Davis 1975, Vermeer et al. 1988). I did not estimate fledging success because monitoring chicks through fledging, particularly on the roofs, likely would have caused excessive investigator-induced mortality.

Age of Incubating Adults

Walk-in traps (Weaver and Kadlec 1970) were placed over nests on TPI and the roofs to capture incubating gulls. Measurements of bill depth, head and bill length (to determine sex and relative age) (Coulson et al. 1981, Fox et al. 1981), and body mass were recorded.

Nest-site Characteristics

To assess whether suitable nesting material was limited, the maximum height and width of each nest on roofs and TPI were measured and a nest volume index (V) was calculated using the equation $V = \pi rn^2(h)$ where r = radius of nest at ground level, and h = height of nest rim above ground. The presence or absence of material suitable to construct a nest within 1 meter of the nest perimeter was recorded. Material was considered present if it was estimated to comprise ≥ 10 percent of the volume of the nest adjacent to it. The percentage of vegetation and garbage (non-food items, e.g., bones, paper, plastic) used as nesting material also was estimated for each nest. Overhead cover within 1 meter of each nest was considered present if ≥ 10 percent of the nest was visually obstructed by objects (e.g., tree limbs, pipes, air vent covers) while an observer looked down directly over the center of the nest from 1 meter above ground. Nests were considered as adjacent to a structure (e.g., vents, skylights) if the center of the next was ≤ 1 meter from a structure. If the nest was constructed against a structure, orientation (nests built against North, East, South or West side of a structure) of the nest was recorded. The type of substrate (gravel, metal or tar) for each roof nest also was recorded. Internest distance was recorded as the distance from the center of each nest to the center of the nest nearest to it. Nests on TPI were classified as located on the edge (areas containing riprap) or center (areas with shrubs or trees present) of the island.

Statistical Analyses

Nest parameters, egg volume indices, hatching dates, and body mass and relative age (via bill depth) between gulls of each sex captured on the roofs and on TPI were compared using *t*-tests. *T*-tests and General Linear Models Procedure with Tukey multiple comparison tests (SAS Institute, Inc. 1988) were used to compare inter-nest distances. Chi-square statistics for proportional data (Fleiss 1973) were used to asses clutch size and the effects of nest-site selection on hatching success. All means are reported with ± 1 standard deviation (SD). Differences were considered significant at $P \leq 0.05$.

Results

Reproductive Parameters

The proportion of nests containing one, two or three eggs was similar ($x^2 = 1.12$, 2 df, $P = 0.55$) for TPI and roof populations, with 77–80 percent containing three eggs (Table 1). The egg volume index differed ($t = 3.17$, 178 df, $P < 0.01$), however, with gulls on roofs laying eggs 4 percent larger than those on TPI (140.1 ± 13.8 ml and 134.1 ± 10.4 ml, respectively). Overall hatching success of eggs from three-egg clutches on roofs (66 percent, $n = 414$) was similar ($x^2 = 1.85$, 1 df, $P = 0.20$) to hatching success on TPI (71 percent, $n = 192$). Gulls on roofs hatched eggs significantly ($t = 12.26$, 232 df, $P < 0.01$) later than did gulls on TPI (May 30 ± 8 days and May 19 ± 6 days, respectively). Estimated mean clutch completion dates for roofs and TPI were May 2 and April 21 respectively.

Age of Incubating Adults

Bill depth of gulls at the two locations was similar ($P \geq 0.15$) for both sexes (Table 2), which suggests that the age structure of the populations was similar. Body mass also was similar ($P \geq 0.87$) for each sex between locations.

Nest-site Characteristics

Nest density on TPI (710 per ha) was greater ($x^2 = 18.23$, 1 df, $P < 0.01$) than on roofs (135 per ha). Similarly, inter-nest distance was less ($t = 7.39$, 234 df, $P < 0.01$) on TPI (2.08 ± 0.86 m, $n = 64$) than on roofs (5.10 ± 3.23 m, $n = 172$). Looking specifically at TPI, inter-nest distance on the riprap (1.75 ± 0.55 m, $n = 45$) was less ($t = 6.00$, 62 df, $P < 0.01$) than was the inter-nest distance in the interior of the island (2.87 ± 0.94 m, $n = 19$). For roofs, inter-nest distance on gravel substrate (4.74 ± 2.74 m, $n = 156$) was less ($F = 14.68$; 2,166 df; $P < 0.01$) than that on other substrates. Inter-nest distance on metal (9.57 ± 6.41 m, $n = 8$) and tar (9.22 ± 3.29 m, $n = 5$) surfaces was similar (Tukey test $P > 0.05$).

Table 1. Clutch size of nesting herring gulls on Turning Point Island (TPI), Sandusky Bay, Lake Erie, and on two roofs in Sandusky, Ohio, 1992.

		Percentage of nests containing			Clutch size	
Location	n	1 egg	2 eggs	3 eggs	$\bar{x}$	SD
TPI	1,875	7	16	77	2.7	0.3
Roofs	176	7	13	80	2.7	0.3

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During the first count of nests on roofs (May 5), 65 percent of nests were adjacent to a structure. Proportionally fewer (x^2 = 17.24, 1 df, P < 0.01) nests initiated after this date were built next to structure (33 percent). For roofs, clutch size was similar (t = −1.63, 169 df, P = 0.11) for gulls nesting adjacent to structure (2.8 ± 0.6, n = 106) and for those that did not (2.7 ± 0.6, n = 65). Egg volume for gulls nesting adjacent to structure ($\bar{x}$ = 179.03 ± 17.45, n = 81) also was similar (t = −0.85, 88 df, P = 0.40) to egg volumes from nests away from structure ($\bar{x}$ = 173.78 ± 18.58, n = 9). In contrast, hatching success was greater (x^2 = 23.32, 1 df, P 0.01) for clutches adjacent to structure (69 percent versus 48 percent). Hatching success also was greater (x^2 = 11.48, 1 df, P < 0.01) for eggs in nests with overhead cover (74 percent versus 58 percent). For gulls that nested against structure, there was no preference for direction in which the next was oriented (x^2 = 0.44, 3 df, P > 0.90). Also, hatching success was unaffected by nest orientation (x^2 = 0.02, 3 df, P > 0.99).

Material suitable for nesting was limited on roofs (x^2 = 134.50, 1 df, P < 0.01), being available at only 3 percent (n = 6) of nests, as compared to 77 percent (n = 51) of nests on TPI. The volume of nests on TPI (13.1 ± 11.0 L) was greater (t = −2.13, 266 df, P = 0.03) than the volume of nests on roofs (10.3 ± 7.8 L). For roofs, nest volumes against structure (10.6 ± 7.9 L, n = 102) were similar (t = −0.62, 162 df, P = 0.53) to volumes of nests away from structure (9.8 ± 7.7 L, n = 62). Percentage volume of garbage was higher (t = 5.09, 228 df, P < 0.01) in nests on roofs (6.7 ± 10.2 percent, n = 166) than in nests on TPI (0.2 ± 0.4 percent, n = 64). Percentage garbage in nests ranged from 0–50 percent. This garbage was not putrescible waste; rather, it included items such as newspaper, cardboard, toothbrushes, wire and brooms.

Discussion

Reproduction

Eggs laid by roof-nesting gulls were significantly larger than those laid by gulls nesting on TPI. Egg size of several species of gulls increases with age to a plateau (Haymes and Blokpoel 1980, Pugesek and Wood 1992). Herring gulls to eight years of age have been reported to lay larger eggs on average, after which they decrease (Davis 1975). However, our index of relative age suggests that the two populations were similar. An alternate explanation is relative fitness of adults. Gulls on roofs laid eggs 11 days later on average

Table 2. Body mass and bill depth (at gonys) of nesting herring gulls on Turning Point Island (TPI), Sandusky Bay, Lake Erie, and on two roofs in Sandusky, Ohio, 1992.

		Body mass (g)			Bill depth (mm)		
Sex	Location	n	$\bar{x}$	SD	n	$\bar{x}$	SD
Male	TPI	11	1,139[a]	128	12	18.30[c]	0.92
	Roofs	5	1,150[a]	88	5	17.57[c]	0.77
Female	TPI	7	976[b]	34	8	16.73[d]	1.28
	Roofs	7	977[b]	61	7	16.15[d]	1.33

[a]Means are not different (t = 0.05, 12 df, P = 0.96).
[b]Means are not different (t = 0.17, 14 df, P = 0.87).
[c]Means are not different (t = −1.54, 15 df, P = 0.15).
[d]Means are not different (t = −0.85, 13 df, P = 0.41).

than did gulls on TPI, allowing additional opportunities to forage before egg laying. Both populations of gulls in this study ate primarily fish (Belant et al. 1993), which are considered "high quality" food for gulls (Pierotti and Annett 1987). Supplemental feeding of fish to gulls has caused an increase in egg size (Hiom et al. 1991, Van Klinken 1992).

There are conflicting results regarding reproductive success of roof-nesting gulls compared with gulls nesting in more traditional areas. Some authors (Mudge 1978, Monaghan 1979, Hooper 1988) have reported fledging success as equal to or greater than that at more traditional sites. Conversely, Vermeer et al. (1988) reported lower reproductive success for densely nesting roof-nesting gulls (but not for dispersed roof-nesting pairs) as compared with island-nesting gulls. Hatching success of eggs between the two populations in this study was similar. Therefore, it is likely that roof and other urban habitats suitable for nesting are similar to more traditional sites in that there is a high degree of variability in habitat quality.

Nest-site Selection

Herring gulls appeared to select areas on roofs adjacent to structures as nest sites. Proportionally fewer later-nesting gulls nested against structure, suggesting that structure is preferred habitat and that the availability of these sites was limited. Although herring gulls had greater hatching success when nesting against structure, there was no apparent preference for orientation of nests. Hooper (1988) similarly found no preference for next orientation in glaucous-winged gulls (*L. glaucescens*) on roofs. Possible causes for nesting against structure include reduction of depredation of eggs and chicks from avian predators or attacks from conspecifics, while maintaining high visibility and an escape route for adults. This may in part explain the higher hatching success of herring gulls nesting against structure in this study.

Temperature also may affect nest-site selection. Although not quantified, the roof surface adjacent to structures is sheltered from direct sun for at least part of the day; thus, adults nesting against structure may sustain lower energetic costs for thermoregulation. Also, daytime temperature appeared to be lower on the gravel surface than on other surfaces which may explain in part the greater density of nests on the light-colored gravel surfaces. Fisk (1978) reported that the daytime temperature of a roof where least terns (*Sterna antillarum*) had nested was 5 degrees Celsius lower than the temperature of a nearby beach where they also nested. If temperature was important for nest-site selection, one would expect unequal distribution in the orientation of nests. However, the aforementioned benefits of nesting near structure may have masked the effects of temperature in nest-site selection as related to nest orientation.

The majority of gulls on TPI nested on the edge of the island on riprap. Advantages to nesting here as compared to the center of the island include greater visibility and a shorter distance to water as an escape mechanism. An apparent disadvantage of nesting near the center of the island is difficulty in accessing the nest. Gulls would either have to pass through several gull territories on the perimeter of the island of maneuver through trees and shrubs during flight. During our visits to the island, we found several adult gulls entangled in tree or shrub limbs.

During this study, nest density was lower on the roofs than on TPI. Other studies have reported similar lower densities on roofs as compared to more traditional sites (Monaghan 1979, Hooper 1988, Vermeer et al. 1988). Vermeer et al. (1988), noting that roofs provide little structure relative to "natural" habitats, observed high conspecific aggression in colonial roof-nesting glaucous-winged gulls. Thus, greater inter-nest distance (i.e., larger territories) may be a strategy used to reduce chick mortality from conspecifics.

Gulls in this study selected roofs adjacent to water for nesting that were near (about 1 km) TPI. Hooper (1988), Vermeer et al. (1988) and Blokpoel et al. (1990) also stated that roof-nesting gulls seem to prefer sites adjacent to water and prefer to colonize sites in close proximity to other occupied sites. Dispersal to more inland sites appears to occur only after saturation of suitable nesting sites near to water.

Conflicts and Control Methods

Nesting by gulls on roofs and in other urban situations has increased markedly in recent years and is likely to continue (Monaghan 1979, Blokpoel and Tessier 1986, Hooper 1988, Vermeer et al. 1988, Vermeer 1992). Increasing numbers of urban-nesting gulls have caused a concurrent increase in gull/people conflicts. Herring gulls are generally considered a nuisance when nesting on buildings because they harass maintenance personnel, defecate on nearby vehicles, obstruct drain pipes with debris and cause structural damage to the roofs of buildings.

Several techniques have been used in attempts to reduce nesting or roosting of gulls on roofs. Although oiling eggs and nest and egg destruction are effective in reducing hatching success, these techniques generally are ineffective for preventing gulls from renesting on buildings (Christens and Blokpoel 1991, Blokpoel and Tessier 1992). Also, because of the breeding longevity of herring gulls, any substantial decrease in nesting population size will likely require several years of nesting failure.

As gulls are federally protected under the Migratory Bird Treaty Act, requiring special federal (and oftentimes state) permits to carry out egg oiling or destruction of eggs and nests, non-lethal techniques to discourage nesting have been employed more frequently. Overhead wires have been used successfully to eliminate ring-billed gulls from nesting and roosting sites (Blokpoel and Tessier 1983, 1984). Gull harassment techniques have been successfully used; however, they are expensive and labor-intensive, requiring persistent repetition for at least several years (Blokpoel and Tessier 1992). The best non-lethal technique to control gull nesting colonies is to modify habitat. Although expensive to implement, the desired effects are more permanent than alternative techniques (Seubert 1990, Blokpoel and Tessier 1992). To reduce the incidence of roof nesting, architectural design (e.g., eliminating or reducing the number of structures on roofs; using dark-colored, non-gravel surfaces; and using overhead wires) should be considered during the planning stage of new buildings in areas where colonization by gulls is likely (e.g., Great Lakes and Atlantic and Pacific coasts) and when roofs of existing buildings require repair or replacement.

Roofs generally have been considered as suboptimal nesting habitat for gulls. Contrary to this hypothesis, herring gulls nesting on roofs during this study were not younger, less experienced birds than those from TPI. I hypothesize that all roofs are not suboptimal habitat, and that preferences within and among roofs and other urban habitats for nest sites exist, similar to preferences within "natural" habitats. Roofs and other urban habitats appear to be a suitable resource for nesting gulls that only have recently been used.

Acknowledgments

I thank personnel from American Quality Stripping and Chesapeake Display and Packaging Company, particularly T. Blauser, for permission to study gulls on the roofs. G.